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The Effect of the Wet Scrubber (Number and Sprayer Diameter) against exhaust emissions (CO_2 and HC)

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Abstract:
Air pollution in cities is caused by motorized and factory activities. Increased pollutant gases cause climate change and the greenhouse effect. Therefore it is necessary to control it. One way is to use a wet scrubber on a motor vehicle and industrial exhausts. The purpose of this study is to reduce motor vehicle exhaust emissions. This research varies the diameter and wet scrubber sprayer on the muffler. The results showed that the more sprayers with smaller diameters the HC gas levels decreased by 11.53%, while the CO_2 levels decreased by 1.04% (number = 3, diameter 200 um at 3000 rpm).

Key Word*: Wet scrubber;Sprayer Number; Sprayer diameter;Exhaust Emissions.*

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I. Introduction

The air pollution of motor vehicles is the main source of carbon monoxide. 50% of air pollution in cities is caused by fossil-fueled transportation. The exhaust emissions causing the greenhouse effect are CO and NOx, while the greenhouse effect can cause global warming. CO and NOx gas levels range between 39.1 and 9.1 million tons per year [1].

The level of carbon monoxide depends on the control of motor vehicle exhaust emissions. in stationary conditions, the exhaust emissions are greater than when it is running. in incomplete combustion, not all hydrocarbons are oxidized, there are still hydrocarbon gases (HC) and carbon monoxide (CO) residues. Carbon monoxide (CO) gas is more dangerous than hydrocarbons [2]–[4].

The previous researchers purified the exhaust gas by adding activated carbon to the muffler[5], [6]. Purification with activated carbon is used as an absorber of exhaust emissions. activated carbon is a material that can absorb gases because it has fine pores on its surface, this material is a material that can reduce levels of exhaust gases. Besides, the use of catalysts, both organic and inorganic [7]–[9]. both of these studies have the potential to purify motor vehicle exhaust gas. "Chemical absorption (in the form of activated carbon) can reduce air pollution[10]. Activated carbon material comes from plants, animals, waste, or minerals that contain carbon[11], [12].

In the industrial world, the wet scrubber system is applied to chimneys to reduce exhaust emissions (smoke, dust, and pollutant gases). Wet scrubber factors that play a role in the exhaust gas flow include spray speed and flow. This system will capture and dissolve pollutant gases into liquid water[13]. The wet scrubber is a system that is applied to chimneys in factories to reduce or eliminate smoke, dust, and pollutant gases resulting from factory activities. A wet scrubber is a system of reducing or purifying industrial pollutant gas by spraying liquid into pollutant gas, so that pollutant gas will be captured by water and make clean gas[14]. The wet scrubber system uses liquid as a pollutant gas cleaner by applying high pressure to the liquid so that a spray occurs to catch the dirty gas. Pollutants come from incomplete combustion processes and produce $CO_2$and HC. To reduce motor vehicle exhaust emissions, one of them is by using exhaust filters [15]. in addition to reducing carbon monoxide gas fly, ash is also used as an adsorbent to reduce exhaust emissions [16]. Besides, the wet scrubber system is used to reduce exhaust emissions in diesel engines[17], [18].

II. Theory

II.1 Incomplete combustion

Incomplete combustion is combustion that occurs as a result of a mixture of fuel igniting itself which is usually not caused by sparks from the spark plug. This condition occurs when the flame does not spread evenly during the combustion process. Incomplete combustion causes gas pressure in the cylinder isn't controlled, this condition is called autoignition. Incomplete combustion reactions that occur in combustion rooms are actual combustion reactions. The reaction that occurs in combustion using isooctane is[19],

$C_8H1_8 + (O_2 + 3{,}73N_2)\ CO + CO_2 + HC + O_2 + NO_x + 3{,}73N_2 + \text{Heat}$ (1)

As a result of incomplete combustion like the combustion process above, detonation and pre-ignition will occur.

II.2 muffler

The muffler is one of the components of a motorized vehicle, mufflers can also be referred to as noise suppression devices mounted on vehicles, mufflers have noise-reducing tubes called dampers[20]. The function of the muffler is to drain the combustion engine gas and stabilize the work of the engine and reduce knock in the combustion chamber. This knock causes a very noisy sound. To reduce the sound/combustion gas coming out of the exhaust valve is not immediately released into the open air. Exhaust gas is channeled to the muffler in the muffler.

In the muffler there is a silencer tube, this depends on the shape of the engine structure. muffler tube function on the vehicle as follows:

a. Reducing harmful gases from vehicle exhaust gases.
b. Slows the speed of the exhaust gas coming out of the muffler.
c. Mutes engine sound.
d. Flowing hot gas combustion engine results.

Exhaust emissions are the residual combustion products of both motorized and industrial vehicles. Exhaust emissions are harmful to humans and living things. The exhaust gas consists of carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NOx) gases. The cause of pollutant gas is incomplete combustion. In a complete combustion reaction, the residual combustion results in the form of gas CO_2, water vapor (H2O), oxygen (O2), and nitrogen (N2). In practice, the combustion that occurs in a vehicle engine does not always run perfectly so the resulting exhaust gas contains very dangerous compounds such as CO, HC, NOx, and particulates. Besides that, the combustion results of fuel oil also contain SO2 and heavy metals (Pb) [21].

III. Method

The design experiment of the exhaust gas testing system as shown in Figure 1.

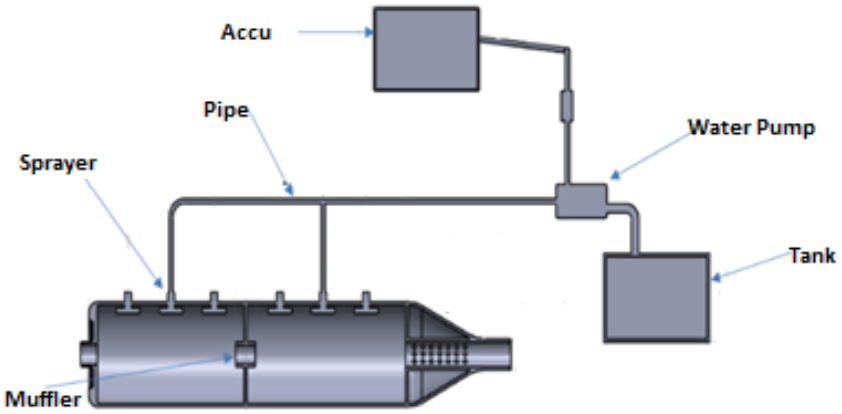

Figure 1. Testing system design

Experiments using motorbikes with fossil fuels. Testing is done by varying the number and diameter of spraying the wet scrub placed on the muffler. only focus on HC and CO_2 exhaust gases. while the experimental set up can be seen in Figure 2.

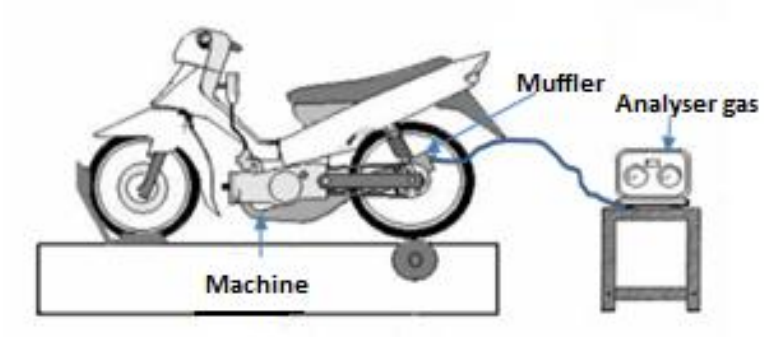

Figure 2 Experimental Set-Up

IV. Result and Discussion

This research was carried out with variations in the number of sprayers (1,2,3), the diameter of the sprayer (100 µm, 200 µm) in the modified exhaust, and variations in engine speed of 3000 rpm, 4500 rpm, and

6000 rpm. The results of testing HC emissions by varying the numberand sprayer diameter of the wet scrubber can be seen in Figure 3.

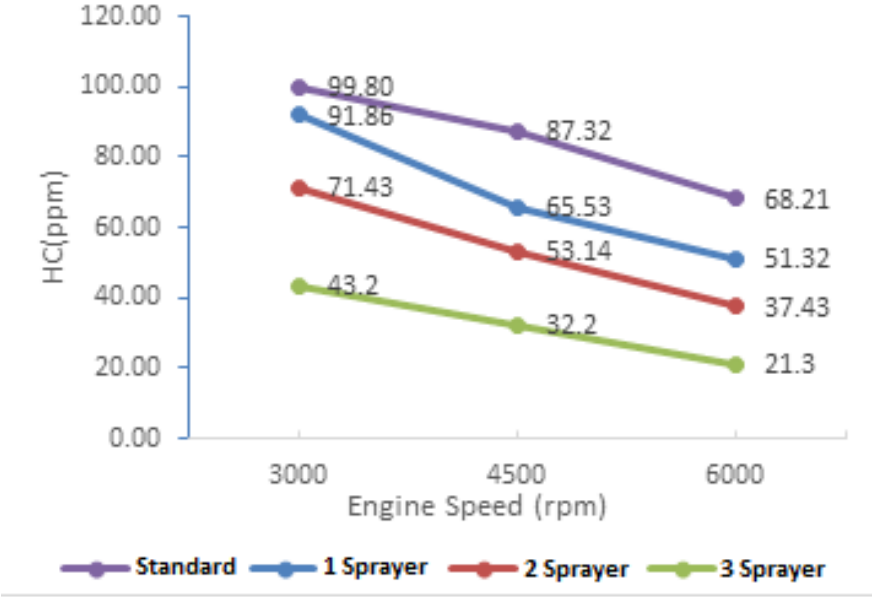

Figure 3. The effect of engine speed on HC gas on variations in the number of sprayers with a diameter of 100 um.

Figure 3 shows a reduction in HC gas emissions. At an engine speed of 3000 rpm, the highest HC gas concentration in 1 sprayer was 91.83%. Whereas at an engine speed of 3000 rpm the HC concentration decreased at 1 sprayer by 21.3%. This decrease is caused when the hydrocarbon gas collides with water vapor, HC gas is captured by water molecules, and is carried away dissolved in it. whereas CO_2 flue gas can be seen in Figure 4.

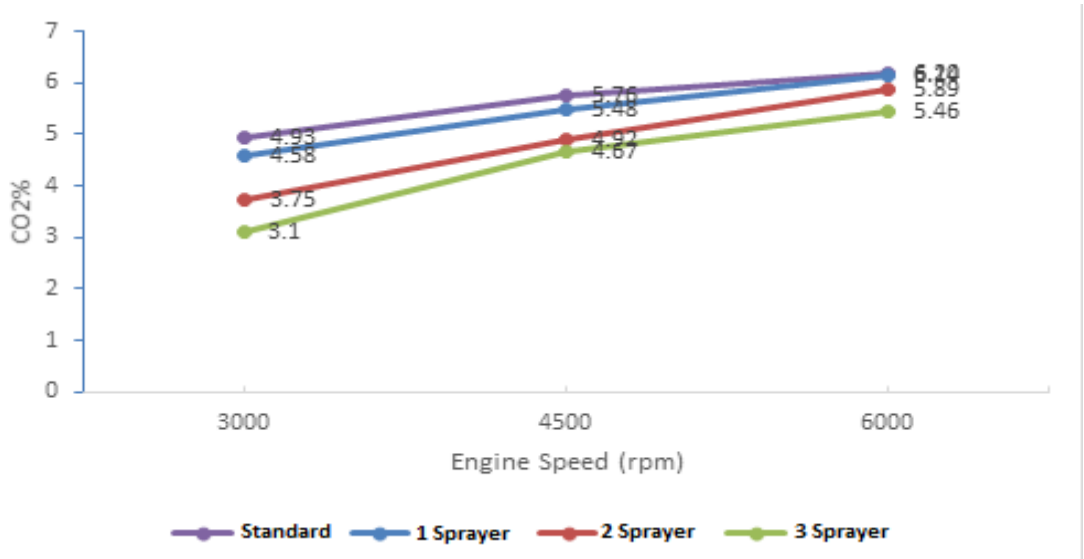

Figure 4. The effect of engine speed on CO_2 gas on variations in the number of sprayers with a diameter of 100 um.

Figure 4 shows a significant reduction in CO_2 gas emissions. At 3000 rpm engine speed, the lowest CO_2concentration with a variation of 3 sprayers is 3.1%. Whereas at 3000 rpm engine speed the highest CO_2concentration with a variation of 1 sprayer is worth 3.14%. There is a decrease in CO_2 gas concentration at each engine speed and variations in the number of sprayers because when the CO_2 gas contracts with liquid gas, CO_2 gas will be caught with the liquid gas, because to bind or react the gas produced requires a high enough temperature, so the water is sprayed with varying the number of a sprayer, sprayer diameter and runner Wet scrubber influence the decrease of the CO_2 gas.

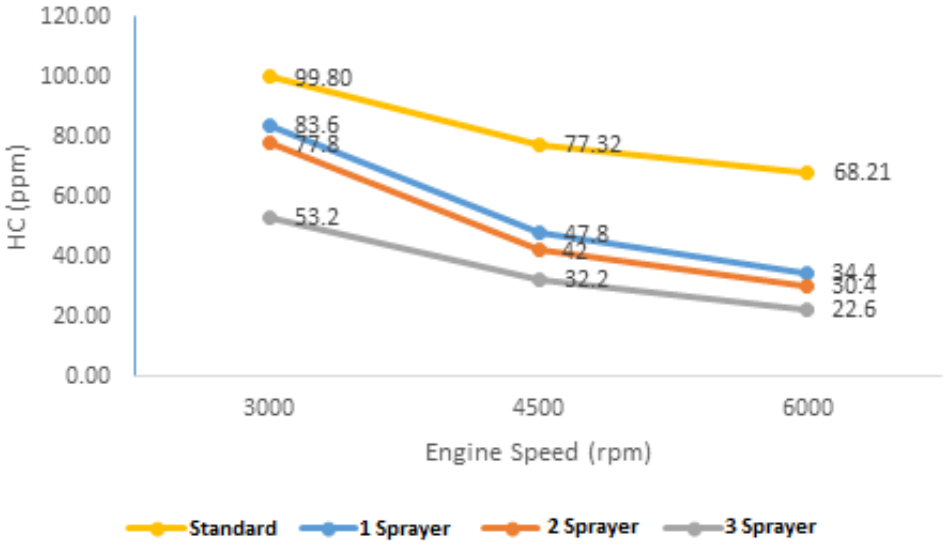

Figure 5. The effect of engine speed on HC gas on variations in the number of sprayers with a diameter of 200 um.

Figure 5 shows a significant reduction in HC gas emissions. At 3000 rpm engine speed, the highest HC concentration with a variation of 1 sprayer is 83.30%. Whereas at 3000 rpm the engine speed of HC levels greatly decreased significantly with a variation of 3 sprayers valued at 22.3%. There is a decrease in HC gas concentration at each engine speed and variations in the number of sprayers, sprayer diameter, the number of wet scrubber chamber because when hydrocarbon gas contracts with liquid gas, HC gas will also be captured with water sprayed so that by adding all variations to the Wet scrubber gas system The resulting HC will decrease.

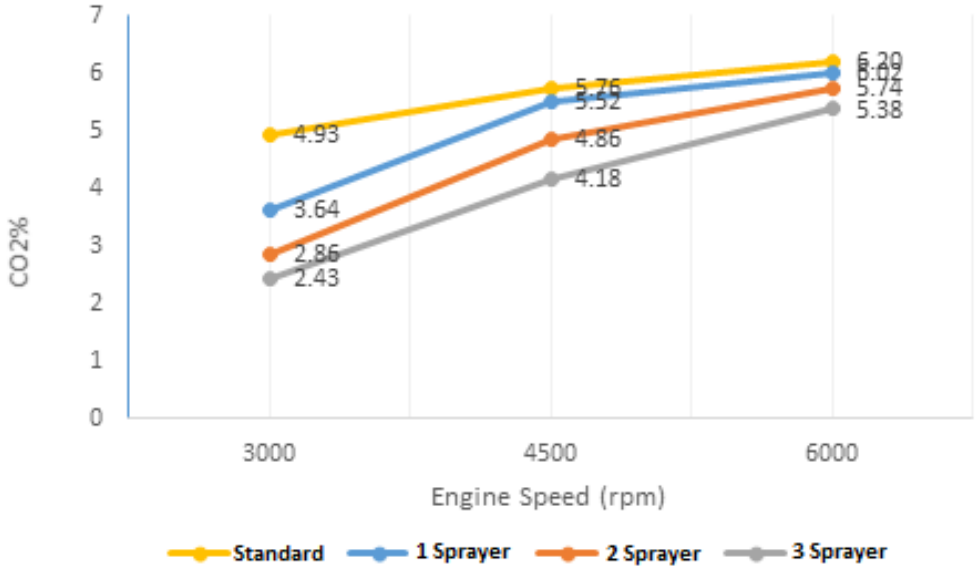

Figure 6. The effect of engine speed on CO_2 gas on variations in the number of sprayers with a diameter of 200 um.

Figure 6 shows a significant reduction in CO_2 gas emissions. At 3000 rpm engine speed, the lowest CO_2concentration with a variation of 3 sprayers is 2.43%. While at 3000 rpm engine speed the highest CO_2concentration with a variation of 1 sprayer is 3.02%. There is a decrease in CO_2 gas concentration at each engine speed and variations in the number of sprayers, sprayer diameter, the number of wet scrubber space because when CO_2 gas contracts with liquid gas, CO_2 gas will be captured by the liquid gas, because to bind the CO_2 gas produced from the combustion process high temperatures are needed, so water sprayed by varying all systems in the Wet scrubber affects the decrease in levels of the CO_2 gas.

The results of exhaust gas emission testing using a wet scrubber k which is applied to the exhaust show a decrease in exhaust gas emissions. The more sprayers and the greater the diameter of the sprayers, the

concentration of exhaust emissions decreases. Because when the exhaust emissions collide with water vapor, the gas will be trapped with water molecules. because the density of water is greater than the flue gas resulting in the flue gas being bound and participating in water molecules. finally, the exhaust gas coming out of the muffler is reduced and clean. the wet scrubber works by capturing pollutant gas particles using water vapor so that it is reduced.

The more the sprayer and the larger the diameter of the hole, the lower the emission of exhaust gases. this is due to the bonding between the exhaust gases and the water vapor molecules. as shown in figure 7.

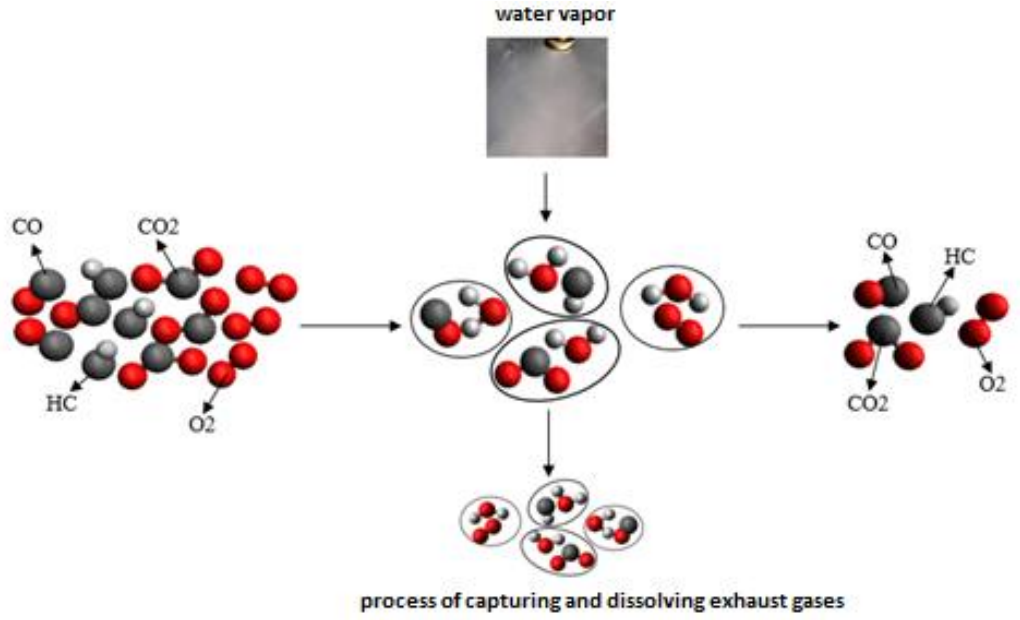

Figure 7 The process of capturing and dissolving exhaust gases with liquid gas.

Because in this application, Wet scrubber in the industry is used to clean pollutant gases from combustion. The wet scrubber system works by capturing pollutant gas particles by misting water vapor, so that dirty pollutant gases can be caught dissolving with the water and the gases released become clean.

V. Conclusions

The conclusions of the study are as follows:

i. The number of sprayers and sprayer diameter Wet scrubber to reduce exhaust emissions is very influential, from each variation given exhaust emissions, especially CO and HC have a significant decrease. The more sprayers and the diameter of the sprayer hole, the greater the emissions of HC flue gas, and the more CO_2 is captured by the liquid gas that is sprayed so that the gas released decreases.
ii. This is indicated by the number of sprayer 3 with a sprayer diameter of 200μm at 3000 rpm turns the HC gas level to 11.53% while the CO_2 gas concentration with the number of variation of 3 sprayers 200 μm sprayer diameter at 3000 rpm turns down the CO_2 gas concentration by 1.04%.

References

[1]. Y. S. H. Najjar, "Gaseous Pollutants Formation and Their Harmful Effects on Health and Environment," Innov. Energy Policies, vol. 1, pp. 1–9, 2011, doi: 10.4303/iep/e101203.
[2]. H. S. K, "Analysis of Exhaust Emissions from Gasoline Powered Vehicles in a Sub-urban Indian Town," Int. Res. J. Environ. Sci., vol. 2, no. 1, pp. 37–42, 2013.
[3]. L. Nerhagen, S. Janhäll, and S. N. R. and T. R. I. (VTI), "Exhaust emissions and environmental classifications of cars: what indicators are relevant according to external cost calculations?," Vti Notat, no. 3A-2015, p. 34, 2015.
[4]. M. Dziubiński, "Testing of exhaust emissions of vehicles combustion engines," Environ. Eng. V - Proc. 5th Natl. Congr. Environ. Eng., pp. 305–310, 2017, doi: 10.1201/9781315281971-43.
[5]. P. J. Villegas, "Preliminary Study of Activated Carbon Filters for Pollutants Removal in Diesel Engines," Int. J. Sustain. Energy Environ. Res., vol. 5, no. 2, pp. 31–45, 2016, doi: 10.18488/journal.13/2016.5.2/13.2.31.45.
[6]. Suhendrayatna, M. Aprianti, P. N. Sheilla, I. Machdar, and E. Elvitriana, "Optimization Process of Carbon Mono Oxide (CO) Gas Emission Adsorption using Activated Carbon from Rice Husk," J. Phys. Conf. Ser., vol. 1114, no. 1, 2018, doi: 10.1088/1742-6596/1114/1/012014.

[7]. P. Taylor, M. H. Valkenberg, and W. F. Hölderich, "Catalysis Reviews : Science and Engineering Preparation and use of hybrid organic-inorganic catalysts," no. October 2012, pp. 37–41, 2007.
[8]. B. Nozière, P. Dziedzic, and A. Córdova, "Common inorganic ions are efficient catalysts for organic reactions in atmospheric aerosols and other natural environments," Atmos. Chem. Phys. Discuss., vol. 9, no. 1, pp. 1–21, 2009, doi: 10.5194/acpd-9-1-2009.
[9]. P. García-García, J. M. Moreno, U. Díaz, M. Bruix, and A. Corma, "Organic-inorganic supramolecular solid catalyst boosts organic reactions in water," Nat. Commun., vol. 7, 2016, doi: 10.1038/ncomms10835.
[10]. A. Mohammad-Khah and R. Ansari, "Activated charcoal: Preparation, characterization, and applications: A review article," Int. J. ChemTech Res., vol. 1, no. 4, pp. 859–864, 2009.
[11]. M. A. Yahya et al., "A brief review on activated carbon derived from agriculture by-product," AIP Conf. Proc., vol. 1972, no. June 2018, doi: 10.1063/1.5041244.
[12]. A. G. Haji, G. Pari, M. Nazar, and H. Habibati, "Characterization of activated carbon produced from urban organic waste," Int. J. Sci. Eng., vol. 5, no. 2, pp. 89–94, 2013, doi: 10.12777/ijse.5.2.89-94.
[13]. A. Bhargava, "Wet Scrubbers – Design of Spray Tower to Control Air Pollutants Wet Scrubbers – Design of Spray Tower to Control Air," Int. J. Environ. Plan. Dev., vol. 2, no. 1, pp. 68–73, 2016.
[14]. S. P. P. Ottengraf, "Exhaust gas purification.," Biotechnol. a Compr. Treatise 8 Vol. Vol. 8, pp. 426–452, 1986.
[15]. T. J. Pilusa, M. M. Mollagee, and E. Muzenda, "Reduction of vehicle exhaust emissions from diesel engines using the whale concept filter," Aerosol Air Qual. Res., vol. 12, no. 5, pp. 994–1006, 2012, doi: 10.4209/aaqr.2012.04.0100.
[16]. B. Sarkan, O. Stopka, J. Gnap, and J. Caban, "Investigation of Exhaust Emissions of Vehicles with the Spark Ignition Engine within Emission Control," Procedia Eng., vol. 187, pp. 775–782, 2017, doi: 10.1016/j.proeng.2017.04.437.
[17]. J. Jeevahan, M. Chandrasekaran, G. Mageshwaran, G. Britto Joseph, and S. Staline, "Investigation of engine performance and emissions of B20 biodiesel blend and effect of EGR on NOx emissions reduction," J. Chem. Pharm. Sci., vol. 9, no. 4, pp. 2469–2473, 2016.
[18]. A. Penconek, B. Zgiet, T. R. Sosnowski, and A. Moskal, "Filtering of DEP (diesel exhaust particles) in fibrous filters," Chem. Eng. Trans., vol. 32, pp. 1987–1992, 2013, doi: 10.3303/CET1332332.
[19]. R. Asatryan, S. Raman, B. Peterson, and J. W. Bozzelli, "Fundamentally Based Reaction Mechanism for Oxidation of Isooctane," no. June 2014, 2011, doi: 10.13140/2.1.3274.0803.
[20]. A. K. M. Mohiuddin, A. Rahman, and Y. Bin Gazali, "Simulation and experimental investigation of muffler performance," Int. J. Mech. Mater. Eng., vol. 2, no. 2, pp. 118–124, 2007.
[21]. P. Brijesh and S. Sreedhara, "Exhaust emissions and its control methods in compression ignition engines: A review," Int. J. Automot. Technol., vol. 14, no. 2, pp. 195–206, 2013, doi: 10.1007/s12239-013-0022-2.

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